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חוק הפטנטים, התשכ"ז -1967
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בקשה לפטנט
Application for Patent

אני, (שם המבקש, מענו – ולגבי גוף מאוגד – מקום התאגדותו)
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בעל בעל אמצאה מכח הדין ששמה הוא:
wner, by virtue of **Operation of Law** of an invention, the title of which is:

(בעברית) **(Hebrew)**
מצלמת FLIR בעלת בקרת גודל שדה הראיה לעומת הרגישות

(באנגלית) **(English)**
A FLIR CAMERA HAVING FOV Vs. SENSITIVITY CONTROL

ereby apply for a patent to be granted to me in respect thereof.
מבקש בזאת כי ינתן לי עליה פטנט.

*בקשת חלוקה- pplication for Division	*בקשת פטנט מוסף- Application for Patent of Addition	*דרישת דין קדימה Priority Claim		
מבקשת פטנט from Application	*לבקשה/לפטנט for Patent/Appl.	מספר/סימן Number/Mark	תאריך Date	מדינת האיגוד Convention Country
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*יפוי כח: ~~כללי/~~ מיוחד רצוף בזה/ ~~עוד יוגש~~
.O.A.: ~~general /~~ specific – attached/ ~~to be filed later~~
Has been filed in case ________ הוגש בענין

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היום 2 בחודש אוקטובר שנת 2003
This 2nd of October 2003

For the Applicant
Attorney Docket No.: 26705

לשימוש הלשכה
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טופס זה, כשהוא מוטבע בחותם לשכת הפטנטים ומושלם במספר ובתאריך ההגשה, הינו אישור להגשת הבקשה שפרטיה רשומים לעיל.

This form, impressed with the Seal of the Patent Office and indicating the number and date of filing, certifies the filing of the application. the particulars of which are set out above.

מצלמת FLIR בעלת בקרת גודל שדה הראיה לעומת הרגישות

A FLIR CAMERA HAVING FOV Vs. SENSITIVITY CONTROL

A FLIR CAMERA HAVING FOV Vs. SENSITIVITY CONTROL

Abstract

1. FLIR cameras that have a large field of view (FOV) and a high spatial resolution at the same time usually use large detector formats such as 640X480 or 1000X1000 or even larger ones. The read out time for such large detector formats takes a relative long time. In many cases the read out time limits the detector exposure time even for low f number systems. Insufficient light collection decreases the signal to noise ratio. Almost all focal plane arrays (FPA) detectors have a "windowing" capability. The windowing capability enables to read out only a fraction out of the total detector sensitive area, for example 160X120 or 320X256 etc. The readout time associated with a small window is much shorter. For example the readout time of the partial matrix 320X240 out of an original matrix of 640X480 is only a quarter of the original time required to read out the entire detector. The spare time may then be used to increase the detector exposure time or to perform several cycles of exposure and readout during one frame period.
2. This patent describes the solutions developed by OPGAL to bridge between two opposite requirements:
   i. High spatial resolution while operating in good atmospheric conditions

   versus

   ii. High sensitivity while operating in bad atmospheric conditions.

Field of the invention

This invention relates to the capability of using high resolution cooled FLIR cameras for two different applications without any hardware modifications. The first application requires a high geometrical resolution combined with a sensitivity between 20mK ($20*10^{-3}$ K) to 30mK ($30*10^{-3}$ K) for example, while the second application requires a high sensitivity of about 1mK (10^{-3} K) or less combined with a reduced geometrical resolution. The reduced geometrical resolution is not part of the requirements but in many cases is a result of the external conditions that limits the performances. Another subject treated in this invention is the criteria implemented to automatically switch between the different operating modes.

Background of the invention

The invention describes a method that enables to tailor FLIR camera performances according to the "quality" of the input video signal. During good atmospheric conditions the FLIR camera uses the entire field of view (FOV). The relative long readout time period enables to perform only one detector exposure period per frame.

The readout circuits implemented as part of the focal plane array are classified into two distinctive categories. The first approach performs detector exposure and after that the readout. This technology is known under names like "snap shot" or "integrate then read" (ITR). The second approach performs the readout in the same time with the detector exposure. This technology is known under the name "integrate while read" (IWR). The second technology requires an additional analog or digital buffer for the entire image. During the readout period both technologies deliver the information collected by the detector on the previous exposure. For example the typical readout time for a detector of 640 by 480 elements is about 10 milliseconds (10^{-2} second) while the readout time for a partial window of 320 by 240 detector elements is only 2.5 milliseconds.

The detector exposure time value is controlled and updated by a closed loop that maintain the average collected charge constant and equal to 70% of the well capacity. The number of exposure periods performed by the detector depends on scenery total radiation and it is independent of the standard video output format. For example for a limited window of 320 by 240 the number of exposure and readout cycles can go till more than 300 cycles per second and for a small window of 64 by 64 it can go high till more than 1000 cycles per second. Assuming that the output video format is 60 frames per second (for example), the largest number of integer exposure readout cycles will be averaged in order to build the external frame. The number of averaged frames is not constant, but depends on scenery radiation as it was mentioned above. This process increases the signal to noise ratio proportional to the square root of the number of exposure readout cycles averaged.

The decision to change the operating mode can be done automatically or manual. The criteria for automatic operating mode change, can be :

- The average signal to noise ratio in the image,
- The maximum signal to noise ratio,
- The minimum signal to noise in the image
- The maximum contrast in the image,
- The minimum contrast in the image,
- The average contrast in the image,
- Any weighting function that combines the above variables.

Detailed description

Large Field of View versus High Sensitivity FLIR camera

1. A FLIR camera based on a two dimensional array detector that converts photons collected from the scenery into photoelectrons, using a closed loop exposure time that maintain a constant average collection of photons independent of scenery radiation,
2. Electronic circuits that read out the charge collected by the detector's element, in a sequenced order and in a controlled format say "window", from the entire detector array say m by n pixels, till some minimum value of m by n pixels located any where on the focal plane array,

2.1 using either the Integrate Then Read (ITR) mode known as "snap shot mode" or

2.2using Integrate While Read (IWR) mode,

3. That performs the sequence - detector exposure, and read out of the new information existing in the window - at the highest *Sequence Rate* dictated by the closed loop exposure time control and the window read out time (that depends on window size):

3.1 for ITR mode the *Sequence Rate* is:

$$Sequence\_Rate = \frac{1}{(Detector\_\exp osure\_time(scenery\_radietion) + \mathrm{Re}ad\_out\_time(m,n))}$$

3.2 for IWR mode the *Sequence Rate* is:

$$Sequence\_Rate = \frac{1}{Maximum(Detector\_\exp osure\_time(scenery\_radietion), \mathrm{Re}ad\_out\_time(m,n))}$$

Where *Maximum(a,b)* chouses the highest value between *a* and *b* .

independent on the video output format,

4. that averages the highest number of integer detector read out sequences included in one output frame time, in order to obtain a maximum signal to noise ratio.
5. The decision to change the window size (m by n pixels) can be done automatically or manual. The criteria for automatic operation can be :
   - The average signal to noise ratio in the window,
   - The maximum signal to noise ratio in the window,
   - The minimum signal to noise in the window,
   - The maximum contrast in the window,
   - The minimum contrast in the window,
   - The average contrast in the window,
   - Any weighting function that combines the above variables or other variables.

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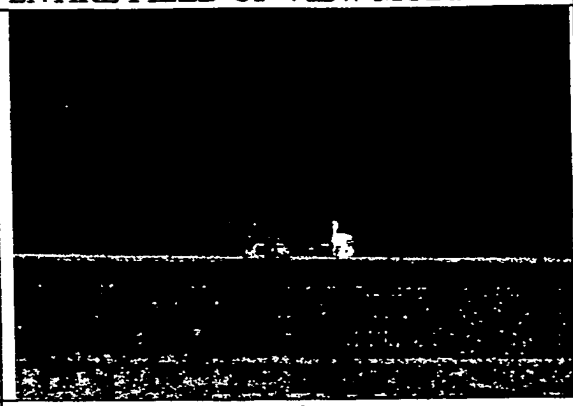
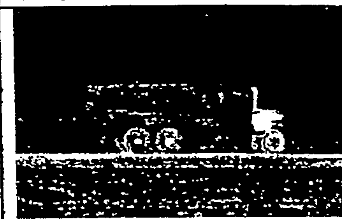
SUBJECT	ENTIRE FIELD OF VIEW MODE	WINDOWING MODE
Moving object. Real pictures collected by 3 to 5 microns FLIR. FLIR f# = 1.5		
Picture size	640 by 480 detector elements	216 by 112 detector elements
Detector exposure time	1.47 milliseconds	1.47 milliseconds
Detector readout time	10.25 milliseconds	0.81 milliseconds
Maximum frame rate at snap shot mode (IDR)	60 Frames/Sec	420 Frames/Sec
Maximum frame rate at integrate while read (IWR)	90 Frames/Sec	660 Frames/Sec
Signal to Noise ratio for snap shot mode	SNR	2.6*SNR
Signal to Noise ratio for IWR mode	SNR	2.7*SNR
Signal to Noise Ratio between IDR mode and IWR windowing mode	SNR	11*SNR

Claims:

1. A FLIR camera configured for automatic optimization between high spatial resolution image capture and rapid image capture, said optimization based on at least one parameter obtained from said image capture.

2. The FLIR camera of claim 1, wherein said parameter is any one of a group comprising:
The average signal to noise ratio in the capture,
The maximum signal to noise ratio in the capture,
The minimum signal to noise in the capture,
The maximum contrast in the capture,
The minimum contrast in the capture,
The average contrast in the capture,
Any weighting function that combines the above variables or other variables.

3. A method of optimizing a FLIR camera for given imaging conditions over a range between high precision slow image capture and low precision rapid image capture, the method comprising:
carrying out image capture at a predetermined point on said range,
measuring a first image parameter from said capture, and
finding a new point on said range that improves said parameter.

4. The method of claim 1, wherein said parameter is any one of a group comprising:
The average signal to noise ratio in the capture,
The maximum signal to noise ratio in the capture,
The minimum signal to noise in the capture,
The maximum contrast in the capture,
The minimum contrast in the capture,
The average contrast in the capture,
Any weighting function that combines the above variables or other variables.

5. A method of optimizing a FLIR camera for given imaging conditions over a range between large field of view slow image capture and small field of view rapid image capture, the method comprising:
carrying out image capture at a predetermined point on said range,
measuring a first image parameter from said capture, and
finding a new point on said range that improves said parameter.

6. A FLIR camera substantially as hereinbefore described.

7. A method of optimizing a FLIR camera substantially as hereinbefore described.

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